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Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

UTILITY PATENT APPLICATION TRANSMITTAL
(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No. 042390.P5698D Total Pages 24

First Named Inventor or Application Identifier **Bhatia**

Express Mail Label No. EL627467075US

ADDRESS TO: **Commissioner of Patents & Trademarks**
Box Patent Application
Washington, D. C. 20231

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents.

1. X Fee Transmittal Form
(Submit an original, and a duplicate for fee processing)

2. X Specification (Total Pages **24**)
(preferred arrangement set forth below)
- Descriptive Title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claims
- Abstract of the Disclosure

3. X Drawings(s) 9 (35 USC 113) (Total Sheets 5)

4. X Oath or Declaration (Total Pages 4)

a. ___ Newly Executed (Original)

b. XXX Copy from a Prior Application (37 CFR 1.63(d))
(for Continuation/Divisional with Box 17 completed) **(Note Box 5 below)**

i. ___ DELETIONS OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).

5. X Incorporation By Reference (useable if Box 4b is checked)
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6.	_______	Microfiche Computer Program (Appendix)
7.	_______	Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
a.	____	Computer Readable Copy
b.	____	Paper Copy (identical to computer copy)
c.	____	Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8.	_____	Assignment Papers (cover sheet & documents(s))
9.	____	a. 37 CFR 3.73(b) Statement (where there is an assignee)
	____	b. Power of Attorney
10.	_____	English Translation Document (if applicable)
11.	____	a. Information Disclosure Statement (IDS)/PTO-1449
	_____	b. Copies of IDS Citations
12.	XX	Preliminary Amendment
13.	XX	Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
14.	____	a. Small Entity Statement(s)
	____	b. Statement filed in prior application, Status still proper and desired
15.	_____	Certified Copy of Priority Document(s) (if foreign priority is claimed)
16.	_____	Other: ______________________

17. **If a CONTINUING APPLICATION,** check appropriate box and supply the requisite information:

____ Continuation   XX Divisional   ____ Continuation-in-part (CIP)

of prior application No: 09/028,203

18. **Correspondence Address**

X Customer Number or Bar Code Label 008791
(Insert Customer No. or Attach Bar Code Label here)

or

X Correspondence Address Below

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FEE TRANSMITTAL FOR FY 2001

TOTAL AMOUNT OF PAYMENT ($)710.00

Complete if Known:
Application No. Unknown
Filing Date Herewith
First Named Inventor Rakesh Bhatia
Group Art Unit Not yet assigned
Examiner Name Not yet assigned
Attorney Docket No. 042390.P5698D

METHOD OF PAYMENT (check one)

1. **[XX] The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:**

   Deposit Account Number 02-2666
   Deposit Account Name BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN, LLP

   [XX] Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17

2. **XX Payment Enclosed:**
   XX Check
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FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	710	201	355	Utility application filing fee	710.00
106	320	206	160	Design application filing fee	
107	490	207	245	Plant filing fee	
108	710	208	355	Reissue filing fee	
114	150	214	75	Provisional application filing fee	

SUBTOTAL (1) $710.00

2. EXTRA CLAIM FEES

			Extra Claims		Fee from below		Fee Paid
Total Claims	9	– 20** =	0	X		=	00
Independent Claims	1	– 3** =	0	X		=	00
Multiple Dependent						=	

****Or number previously paid, if greater; For Reissues, see below.**

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	80	202	40	Independent claims in excess of 3
104	270	204	135	Multiple dependent claim, if not paid
109	80	209	40	**Reissue independent claims over original patent
110	18	210	9	**Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) $710.00

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for response within first month	
116	390	216	195	Extension for response within second month	
117	890	217	445	Extension for response within third month	
118	1,390	218	695	Extension for response within fourth month	
128	1,890	228	945	Extension for response within fifth month	
119	310	219	155	Notice of Appeal	
120	310	220	155	Filing a brief in support of an appeal	
121	270	221	135	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive unavoidably abandoned application	
141	1,240	241	620	Petition to revive unintentionally abandoned application	
142	1,240	242	620	Utility issue fee (or reissue)	
143	440	243	220	Design issue fee	
144	600	244	300	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	710	246	355	For filing a submission after final rejection (see 37 CFR 1.129(a))	
149	710	249	355	For each additional invention to be examined (see 37 CFR 1.129(b))	
179	710	279	355	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	

Other fee (specify) ______________________ ________

Other fee (specify) ______________________ ________

SUBTOTAL (3) $710.00

*Reduced by Basic Filing Fee Paid

SUBMITTED BY:

Typed or Printed Name: Jeffrey S. Draeger

Signature: [signature] **Date:** October 5, 2000

Reg. Number: 41,000 **Telephone Number:** 408-720-8300

Docket No.: 42390.P5698D

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of:	
Bhatia	
Serial No.: not yet assigned	Examiner: Not yet assigned
Filed: herewith	Art Unit: Not yet assigned
<u>Divisional of</u> Serial No.: 09/028,203 Filed: 2/23/98	
For: A HEAT EXCHANGER FOR A PORTABLE COMPUTING DEVICE UTILIZING ACTIVE AND PASSIVE HEAT DISSIPATION MECHANISMS	

<u>PRELIMINARY AMENDMENT</u>

Commissioner for Patents
and Trademarks
Washington, D.C. 20231

Dear Sir:

Please enter the following preliminary amendment in conjunction with applicant's divisional application filed herewith.

IN THE CLAIMS

Please cancel without prejudice claims 1-6.

7. (Amended) [The heat exchanger of claim 1 wherein the at least one heat transfer mechanism comprises:]A heat exchanger comprising

a first heat dissipation mechanism having a first heat dissipation capacity;

a second heat dissipation mechanism having a second heat dissipation capacity;

a variable thermal conductivity heat pipe having a first portion thermally coupled to [the]a heat generating component, a second portion thermally coupled to the first heat dissipation mechanism, and a third portion separated from the first portion and the second portion by [the]a limited conductivity portion and thermally coupled to the second heat dissipation mechanism.

8. (Amended) The heat exchanger of claim [1]7 wherein the [at least one heat transfer mechanism]variable thermal conductivity heat pipe has a first thermal path with a first thermal conductivity which couples the heat generating component to the first heat dissipation mechanism and has a second thermal path with a second thermal conductivity which couples the heat generating component to the second heat dissipation mechanism and wherein the first thermal conductivity is at least twice the second thermal conductivity and the first heat dissipation mechanism is an active heat dissipation mechanism.

9. (Amended) The heat exchanger of claim [8]7 wherein the heat generating component is a processor and wherein the second thermal conductivity is approximately four times the first thermal conductivity.

10. (Amended) The heat exchanger of claim [8]7 wherein the first heat dissipation mechanism is an active heat dissipation mechanism that is enabled depending on at least the temperature of the heat generating component.

11. (Amended) The heat exchanger of claim [1]7 wherein the first heat dissipation mechanism is a fan based heat exchanger and wherein the second heat dissipation mechanism is a thermally conductive plate beneath and substantially parallel to a keyboard.

Please cancel without prejudice claims 13-16.

Please cancel without prejudice claims 22-26.

27. (New) An apparatus comprising:

at least one electronic component;

a heat pipe having a limited conductivity portion, the heat pipe having a first portion thermally coupled to the at least one electronic component;

a fan based heat exchanger thermally coupled to a second portion of the heat pipe;

a metallic plate coupled to a third portion of the heat pipe and separated from the first portion that is connected to the at least one electronic component by the limited conductivity portion of the heat pipe.

28. (New) The apparatus of claim 27 wherein the metallic plate comprises a plate substantially beneath a keyboard.

29. (New) The apparatus of claim 27 wherein said limited thermal conductivity portion of said heat pipe comprises a narrowed portion of said heat pipe.

30. (New) The apparatus of claim 28 wherein the metallic plate comprises a portion of a thermally enhanced keyboard.

REMARKS

Applicant submits that all claims now pending are in condition for allowance at least by

way of dependency on an allowable independent claim. Such action is earnestly solicited at the earliest possible date. If there is a deficiency in fees, please charge our Deposit Acct. No. 02-2666.

Respectfully submitted,

Date: October 5, 2000

Jeffrey S. Draeger, Reg. No. 41,000

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Signed by: Julie K. Mausen Date Signed: October 5, 2000
Julie K. Mausen

UNITED STATES UTILITY PATENT APPLICATION

FOR

A HEAT EXCHANGER FOR A PORTABLE COMPUTING DEVICE UTILIZING ACTIVE AND PASSIVE HEAT DISSIPATION MECHANISMS

Inventors:

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42390.P5698

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A HEAT EXCHANGER FOR A PORTABLE COMPUTING DEVICE UTILIZING ACTIVE AND PASSIVE HEAT DISSIPATION MECHANISMS

Background of the Invention

1. Field of the Invention

The present invention pertains to the field of heat dissipation in an electronic device. More particularly, the present invention pertains to the use of multiple heat dissipation mechanisms to cool one or more electronic components.

2. Description of Related Art

Faster and more powerful computer components allow the design and construction of higher performance portable computing devices such as laptop or notebook computers. Unfortunately, the use of such faster and more powerful computer components often results in increased heat generation by such computing devices.

Additionally, as some computer components shrink and/or increasing computer component integration shrinks overall computer size, electronic components may be arranged in a more compact form. Such increasing component density coupled with decreasing overall computing device size inherently decreases space available for convective airflow and accordingly raises heat dissipation concerns. Thus, improved heat dissipation technology is often needed to maintain operating temperatures

within an acceptable range in smaller and/or more powerful portable computing devices.

Maintaining operating temperatures of computer system components below certain levels is important to ensure performance, reliability, and safety. Most integrated circuits have specified maximum operating temperatures, above which the manufacturer does not recommend operation. Additionally, transistors on an integrated circuit tend to slow down as operating temperature increases. Thus, a computer system that operates its integrated circuits close to or beyond recommended timings may fail as temperature increases.

Additionally, integrated circuits may be physically damaged if temperatures elevate beyond those recommended. Such physical damage obviously can impact system reliability. Finally, the computer system casing should be kept at a temperature which is safe for human contact. This may necessitate spreading of heat throughout a computer system base or efficiently expelling heat to avoid hot spots near certain components such as a processor.

One prior art technique for cooling an electronic component in a portable computing device is to conduct heat from the electronic component to a plate beneath the device's keyboard using a heat pipe affixed by a heat conductive block to the electronic component. As increasing amounts of heat are generated by the electronic component, this technique may cause the plate beneath the keyboard and hence the keyboard to reach temperatures which are too hot for safe or comfortable use. Thus, such passive heat dissipation techniques may prove insufficient in some applications.

Active techniques have also been employed to cool electronic components in portable computing devices. One example of a prior art active heat dissipation technique is to use a fan based heat exchanger. In one prior art approach, a thermal connection exists between an electronic component and a fan based heat exchanger having heat dissipation fins. The thermal connection includes a thermal block connecting the electronic component to the heat pipe and, in some cases, the heat pipe being connected to the heat dissipation fins through an outer casing of the heat exchanger.

Each additional element in the thermal path from the heat generating component to the heat dissipation mechanism may result in decreased thermal conductivity between the electronic component and the heat dissipation fins. As a result, a thermal path from the electronic component to the fins having numerous elements may be somewhat inefficient. Moreover, if active heat dissipation is the only mechanism provided for heat dissipation, the active dissipation is likely necessary when the portable computing device is relying on battery power. Consequently, the active thermal solution may disadvantageously drain the battery.

Thus, the prior art does not adequately combine multiple heat dissipation mechanisms to cool portable computing devices. The prior art also does not provide a combination active and passive thermal solution which enables the active dissipation mechanism at a varying power level based on temperature and/or power source. Furthermore, the prior art does not demonstrate the use of multiple heat dissipation mechanisms where a passive heat dissipation mechanism is coupled to a heat generating component by a thermal path having a limited thermal

conductivity portion to limit the amount of heat dissipated by the passive heat dissipation mechanism.

Summary

A heat exchanger is disclosed. The heat exchanger includes a first heat dissipation mechanism having a first heat dissipation capacity and a second heat dissipation having a second heat dissipation capacity. At least one heat transfer mechanism thermally couples the first heat dissipation mechanism and the second heat dissipation mechanism to a heat generating component. The heat transfer mechanism has a limited conductivity portion in the thermal path to either the first or the second heat dissipation mechanism.

Brief Description of the Figures

The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings.

Figure 1 illustrates one embodiment of a portable computing device.

Figure 2a illustrates a front cross sectional view of one embodiment of the attachment of a heat dissipation mechanism to a heat generating component.

Figure 2b illustrates a side cross sectional view of the embodiment of Figure 2a taken along section line 2B-2B.

Figure 3A illustrates a front cross sectional view of the attachment of a heat dissipation mechanism to a heat generating component according to another embodiment.

Figure 3b illustrates a side cross sectional view of the embodiment of Figure 3a taken along section line 3B-3B.

Figure 4 illustrates one embodiment of the use of a variable conductivity heat pipe.

Figure 5 illustrates one embodiment of a method for cooling a heat generating component.

Detailed Description

The following description provides a heat exchanger utilizing active and passive mechanisms. In the following description, numerous specific details such as particular component sizes and types as well as particular physical locations for components and heat dissipation mechanisms are set forth in order to provide a more thorough understanding of the present invention. It will be appreciated, however, by one skilled in the art that the invention may be practiced without such specific details.

The present invention advantageously utilizes multiple heat dissipation devices to cool a portable computing device. In one embodiment, active and passive heat dissipation devices are used, such that the active heat dissipation device may be enabled at a power level which may vary depending on whether the heat generating component is operating at a certain power or temperature level or in a particular mode, such as when external power is applied. Furthermore, one embodiment utilizes a limited thermal conductivity portion in a thermal path and may therefore provide separate thermal paths which have thermal conductivities proportional to the heat dissipation capacity of the different heat dissipation devices connected thereto. Such varying thermal conductance may allow a keyboard to maintain an acceptable temperature by limiting the amount of heat transferred to a heat dissipation plate beneath the keyboard.

Figure 1 illustrates a portable computing device 100. The portable computing device may be a notebook or laptop computer or

another type of computing device such as a personal organizer, personal digital assistant, or any similar type of computing device. Additionally, the heat exchanger may be utilized in non-portable computing devices.

A base portion 105 of the portable computing device 100 includes a thermally enhanced keyboard (TEK) 102. In one embodiment, the TEK includes a keypad 108 and a keyboard plate 110 which may be used to dissipate heat through the keypad 108. In another embodiment, the keyboard plate 110 may be one or more flat heat pipes which are integrally formed or otherwise affixed beneath the keypad 108. An integral keyboard and heat pipe is described in US patent application no. 08/854,185 entitled "Integral Keyboard and Heat Pipe," filed May 9, 1997, which is hereby incorporated by reference.

The base portion 105 includes a motherboard 115 which is connected to a processor module 130 by connectors 117a and 117b. In the illustrated embodiment, two heat generating components are mounted on the processor module 130. In one embodiment, these heat generating components are a processor 140 and a bridge 145. In other embodiments, other integrated circuits or the module 130 itself may be cooled.

In the illustrated embodiment, a heat pipe 120 has a first portion 120a which is thermally coupled to the bridge 145 and the processor 140. This first portion 120a of heat pipe 120 may be flattened as it contacts the processor 140 and the bridge 145. The heat pipe 120 may then return to a cylindrical shape as it moves away from the module 130. Alternatively, the entire heat pipe 120 may be flat or may be formed into any shape which can be thermally coupled to heat generating components such as the processor 140 and the bridge 145.

A second portion 120b of the heat pipe 120 extends away from the module 130 toward a rear corner of the base portion 105. At the rear corner of the base portion 105 is an active heat dissipation device, in this embodiment a fan based heat exchanger 160. The fan based heat exchanger 160 forms a duct which channels air driven by a fan 170. Heat dissipation fins 165 are directly welded to the heat pipe 120 to minimize the number of interfaces through which the heat must pass. Additionally, the outer housing of the heat exchanger 160 may be a heat conductive material and may also be welded to the second portion 120b of heat pipe 120.

In alternative embodiments, the fins and duct may be otherwise arranged. It is generally preferred to directly attach the fins to the heat pipe or extrude the fins and the heat pipe as one unified body. For example, a flat heat pipe may be extruded to have fins extending perpendicular to flat portions of the heat pipe. With the fins extending from the heat pipe (especially if fins extend axially in all directions from the heat pipe), the duct which channels air may be formed by plastic or other materials.

The passive portion of the heat exchanger is formed by the keyboard plate 110. The keyboard plate 110 is thermally coupled to the processor 140 and the bridge 145 via a heat path which includes a limited conductivity portion (a heat transfer block 150 in this embodiment) to limit the amount of heat transferred to the passive element (the keyboard plate 110). As illustrated, the heat transfer block 150 may have grooves on one surface thereby limiting the amount of surface contact and hence the thermal conductivity along the thermal path to the passive heat dissipation device.

Further details of one embodiment of the connection between the heat pipe 120 and the heat generating components are shown in Figure 2a. The processor 140 shown in Figure 1 includes a processor die 205 as well as a number of contacts (not shown) for making electrical connections with the processor module 130. In this embodiment, the first portion 120a of the heat pipe 120 is directly connected to the processor 205. A thermal grease or other similar material such as a compressive and thermally conductive elastomer may be used to enhance the thermal transfer characteristics of the direct connection between the processor die 205 and the heat pipe 120. In contrast, prior art techniques typically employ a thermal transfer block or a slug between a processor die and a heat pipe.

According to the embodiment illustrated in Figure 2a, the thermally conductive heat transfer block 150 is fastened on top of the processor die 205 and the heat pipe 120. The heat transfer block 150 is fastened to the processor module 130 by four fasteners, one on each corner. From the illustrated perspective, only two fasteners may be seen, fasteners 210a and 210b. The heat transfer block 150 in this embodiment includes grooves 220 which reduce the thermal conductivity of the thermal path from the processor die 205 and the bridge 145 to the keyboard plate 110. Indeed, only the ridge portions such as the ridge 230 contact the keyboard plate. A particular thermal conductivity may be achieved by adjusting the groove/ridge arrangement.

A decreased thermal conductivity (higher thermal resistance or theta) is intentionally produced in order to limit the heat transferred to the keyboard plate. If too much heat is transferred to the keyboard plate 110, the keyboard may become dangerously hot or at least may

exceed a desired maximum temperature. Thus, the thermal conductivity of this path may be set by adjusting the thermal conductivity of the limited conductivity portion (i.e., in this embodiment the grooved block) of the path.

The thermal conductivity selected for the thermal path from the processor die 205 to the keyboard plate 110 and the thermal conductivity of the thermal path from the processor die 205 to the fan based heat exchanger 160 are proportional to the heat dissipation capacity of the keyboard plate 110 and the heat dissipation capacity of the fan based heat exchanger 160. In other words, the thermal conductivities may be selected such that their ratio equals or is similar to the ratio of the heat dissipation capacities.

The heat dissipation capacity for the keyboard plate 110 is defined as the amount of heat the keyboard plate 110 can dissipate while remaining in the desired operating temperature range. The heat dissipation of the fan based heat exchanger 160 may vary with the power level (e.g., off, minimum, maximum, etc.) the fan 170. Thus, the ratio may be matched for a particular power level of the fan as needed to assure that the keyboard maintains an acceptable temperature. Since a variety of fan speeds may be used, the fact that thermal paths are proportional to heat dissipation capacities does not imply that a strict mathematical equality of ratios must exist. Rather, the relative heat dissipation capacities are reflected in the respective thermal paths by the same general relationship (e.g., greater than, less than, approximately twice, etc.).

In one embodiment, the processor die 205 is capable of generating up to approximately twenty watts. Of this power, approximately four

watts may be safely dissipated using the keyboard plate 110. The remaining heat may be dissipated via the active heat dissipation mechanism. Thus, in this embodiment, the thermal path to the active heat dissipation mechanism (e.g., the fan based heat exchanger 160) has approximately four times the thermal conductivity of the thermal path to the keyboard plate 110. In other embodiments, this ratio may vary substantially. Not only does the ratio depend on the heat dissipation capacity of both the active and passive mechanisms, but it also may depend on the total amount of heat generated by the heat generating devices and whether the devices can operate in different power consumption modes.

A side view of the arrangement of Figure 2a as taken through section line 2B-2B of Figure 2a is shown in Figure 2b. Figure 2b illustrates that the first portion 120a of the heat pipe 120 may be flattened to contact the processor die 205 with a larger surface area than might be possible with a cylindrical heat pipe. Indeed, in some embodiments, the entire heat pipe 120 may be flat or rectangular. Figure 2b also illustrates how the heat transfer block conforms to the shape of the portion of the heat pipe 120 which is directly attached to the processor die 205. Additionally, Figure 2b illustrates one of the rear fasteners, fastener 210c.

Figures 3a and 3b illustrate one alternative embodiment of the heat transfer block 150. Figure 3b illustrates a side cross section view of the embodiment of Figure 3a taken through section lines 3B-3B. As illustrated in these figures, the limited conductivity portion of the thermal path away from the heat generating components may be formed using a hollow heat transfer block 305 which has a cavity 310 filled

with a material having a lower thermal conductivity than the outer surface of the heat transfer block 305. In one embodiment, the heat transfer block 305 is aluminum and the cavity is filled with air. The exact materials used are not crucial, and varying conductivities may be achieved by varying either the materials or the proportion of the highly conductive material to that which is not.

Figure 4 illustrates one alternative embodiment which utilizes a variable thermal conductivity heat pipe 400 with two portions 405 and 415 to provide the two different thermal paths to the active and passive heat dissipation mechanisms. In this embodiment, a throttling portion 410 of the heat pipe 400 forms the limited conductivity portion which allows a smaller amount of heat to be transferred the passive heat dissipation mechanism, the keyboard plate 440.

The throttling portion 410 may be formed during manufacture of the heat pipe 400 or may be mechanically produced by pressure or bending of the heat pipe 400. The throttling portion 410 could also be formed by using a throttle valve which internally narrows the heat pipe and thereby limits heat flow. Alternatively, the heat pipe 400 may be pinched such that the first portion 405 and the second portion 415 form separate evaporator and condenser portions. One further alternative is for the first portion 405 to be a heat pipe and the second portion to include a gas reservoir separated from the heat pipe portion by a vapor-gas interface. The vapor-gas interface allows heat to be transferred between the two portions but keeps the vapor from the heat pipe portion separate from a gas (e.g., an inert gas) in the gas reservoir portion.

Thus the limited conductivity portion may include a throttling portion and another high thermal conductivity portion or may include an

entire portion having lower thermal conductivity. In any case, the limited conductivity portion may be used to limit the flow of heat to the keyboard plate 440 to apportion heat from the processor die 205 to the active heat dissipation mechanism and the keyboard plate 440 such the heat keyboard remains at an acceptable temperature.

Additionally, an optional heat transfer block 430 may be used to thermally couple the second portion 415 of the heat pipe 400 to the keyboard plate 440. The heat transfer block 430 may not be necessary if the heat pipe 400 is bent or otherwise arranged such that a direct connection to the keyboard plate may be made. On the other hand, the heat transfer block 430 may also be used to limit the heat flow to the keyboard plate 440. The heat transfer block 430 is not required because the variable thermal conductivity heat pipe 400 may alone limit the conductivity of the path to the keyboard plate 440.

Figure 5 illustrates one embodiment of a method of utilizing active and passive heat dissipation components. As shown in block 505, a first thermal path for transferring heat to a passive heat dissipation mechanism is provided. This first thermal path has a thermal resistance of θ_1. A second thermal path to an active heat dissipation mechanism is provided as shown in block 510. The first thermal path has a substantially greater thermal resistance than the thermal resistance of the second thermal path(θ_2). For example, θ_1 may be at least twice θ_2.

As shown in block 515, the system senses power and/or thermal conditions to determine if active cooling is needed. In a portable computing device, the processor may include a temperature sensor, and other temperature sensors may be included on circuit boards or other computer system components such as CD ROM drives. Additionally, it may

be sensed whether external (e.g., alternating current) power is being supplied.

Depending on the various temperature measurements and whether external or battery power is being supplied, the active cooling mechanism may be enabled as shown in block 520. In fact, an active cooling mechanism such as a fan may be capable of operating at a number of power levels depending on these conditions. For example, the temperature which first causes a fan to be enabled may be higher if the system is operating on battery power.

As shown in block 525, whether or not the active heat dissipation mechanism is enabled, the passive heat dissipation mechanism may be used. In conjunction with the variable cooling available from the active heat dissipation mechanism, this combination can provide an intelligent system which provides multiple levels of heat dissipation and limits battery consumption.

Thus, the present invention provides a heat exchanger utilizing active and passive mechanisms. While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those ordinarily skilled in the art upon studying this disclosure.

What is claimed is:

1. A heat exchanger comprising:

a first heat dissipation mechanism having a first heat dissipation capacity;

a second heat dissipation mechanism having a second heat dissipation capacity;

at least one heat transfer mechanism thermally coupling the first heat dissipation mechanism and the second heat dissipation mechanism to a heat generating component, the at least one heat transfer mechanism having a limited conductivity portion in a thermal path to one of the first and second heat dissipation mechanisms.

2. The heat exchanger of claim 1 wherein the at least one heat transfer mechanism has a first thermal path and a second thermal path which have respectively a first and a second thermal conductance proportional to the first and the second heat dissipation capacity.

3. The heat exchanger of claim 1 wherein the at least one heat transfer mechanism comprises:

a heat pipe thermally coupled to the heat generating component; and

a heat transfer block which forms the limited conductivity portion, the heat transfer block being thermally coupled to the heat generating component.

4. The heat exchanger of claim 3 wherein the heat transfer block is a grooved heat transfer block having a plurality of grooves on a surface which is a part of the second thermal path.

5. The heat exchanger of claim 3 wherein the heat transfer block is a hollow heat transfer block having an outer surface and an internal cavity, the internal cavity containing a material having a lower thermal conductivity than the outer surface of the heat transfer block.

6. The heat exchanger of claim 1 wherein the heat generating component is an integrated circuit having an integrated circuit die, and wherein the at least one heat transfer mechanism includes a heat pipe having a first portion directly attached to the integrated circuit die, and further wherein the heat pipe has a second portion which is a part of the second heat dissipation mechanism and to which a plurality of heat dissipation fins are directly welded.

7. The heat exchanger of claim 1 wherein the at least one heat transfer mechanism comprises:

a variable thermal conductivity heat pipe having a first portion thermally coupled to the heat generating component, a second portion thermally coupled to the first heat dissipation mechanism, and a third portion separated from the first portion and the second portion by the limited conductivity

portion and thermally coupled to the second heat dissipation mechanism.

8. The heat exchanger of claim 1 wherein the at least one heat transfer mechanism has a first thermal path with a first thermal conductivity which couples the heat generating component to the first heat dissipation mechanism and has a second thermal path with a second thermal conductivity which couples the heat generating component to the second heat dissipation mechanism and wherein the first thermal conductivity is at least twice the second thermal conductivity and the first heat dissipation mechanism is an active heat dissipation mechanism.

9. The heat exchanger of claim 8 wherein the heat generating component is a processor and wherein the second thermal conductivity is approximately four times the first thermal conductivity.

10. The heat exchanger of claim 8 wherein the active heat dissipation mechanism is enabled depending on at least the temperature of the heat generating component.

11. The heat exchanger of claim 1 wherein the first heat dissipation mechanism is a fan based heat exchanger and wherein the second heat dissipation mechanism is a thermally conductive plate beneath and substantially parallel to a keyboard.

12. The heat exchanger of claim 11 wherein the second heat dissipation capacity is determined in part by a maximum acceptable operating temperature for the keyboard.

13. A system comprising:

an electronic component;

a heat pipe thermally coupled to the electronic component;

a fan based heat exchanger thermally coupled to the heat pipe;

a heat transfer block thermally coupled to the electronic component; and

a thermally enhanced keyboard thermally coupled to the heat transfer block.

14. The system of claim 13 wherein the electronic component is a processor having a processor die and a plurality of contacts, and wherein the heat pipe is directly connected to the processor die.

15. The system of claim 13 wherein the thermally enhanced keyboard comprises:

a keyboard; and

a heat dissipation plate affixed beneath and substantially parallel to a substantial portion of the keyboard.

16. The system of claim 13 wherein the thermally enhanced keyboard comprises:

a keyboard; and

at least one flat heat pipe affixed beneath and substantially parallel to a substantial portion of the keyboard.

17. A system comprising:

an electronic component;

a variable thermal conductivity heat pipe having a first portion and a second portion separated by a throttling portion, the electronic component being thermally coupled to the first portion; and

a first heat dissipation mechanism thermally coupled to the first portion of the variable thermal conductivity heat pipe; and

a second heat dissipation mechanism thermally coupled to the second portion of the variable thermal conductivity heat pipe.

18. The system of claim 17 wherein the first heat dissipation mechanism is a fan based heat exchanger including a fan and a plurality of fins which are directly welded to the heat pipe.

19. The system of claim 18 wherein the plurality of fins are directly welded to the heat pipe.

20. The system of claim 18 wherein the plurality of fins are integrally formed with the heat pipe.

21. The system of claim 18 wherein the second heat dissipation mechanism is a heat dissipation plate affixed beneath and substantially parallel to a keyboard.

22. A method of cooling an electronic component comprising:

sensing conditions during operation of the electronic component to determine whether active cooling is needed;

enabling an active heat exchanger if active cooling is needed; and

dissipating heat through a passive heat dissipation plate regardless of whether external power is being supplied.

23. The method of claim 22 wherein the sensing comprises sensing a temperature of the electronic component.

24. The method of claim 23 wherein the sensing further comprises sensing whether external power is being provided.

25. The method of claim 24 wherein the step of enabling comprises:

enabling a fan at a power level dependent on the temperature of the electronic component and whether external power is being supplied.

26. The method of claim 22, further comprising:

transferring heat via a first thermal path having a first thermal conductivity from the electronic component to an active heat dissipation mechanism;

transferring heat via a second thermal path having a second thermal conductivity from the electronic component to the passive heat dissipation mechanism, the first thermal conductivity being at least twice the second thermal conductivity.

Abstract

A heat exchanger. The heat exchanger includes a first heat dissipation mechanism having a first heat dissipation capacity and a second heat dissipation having a second heat dissipation capacity. At least one heat transfer mechanism thermally couples the first heat dissipation mechanism and the second heat dissipation mechanism to a heat generating component. The heat transfer mechanism has a limited conductivity portion in the thermal path to either the first or the second heat dissipation mechanism.

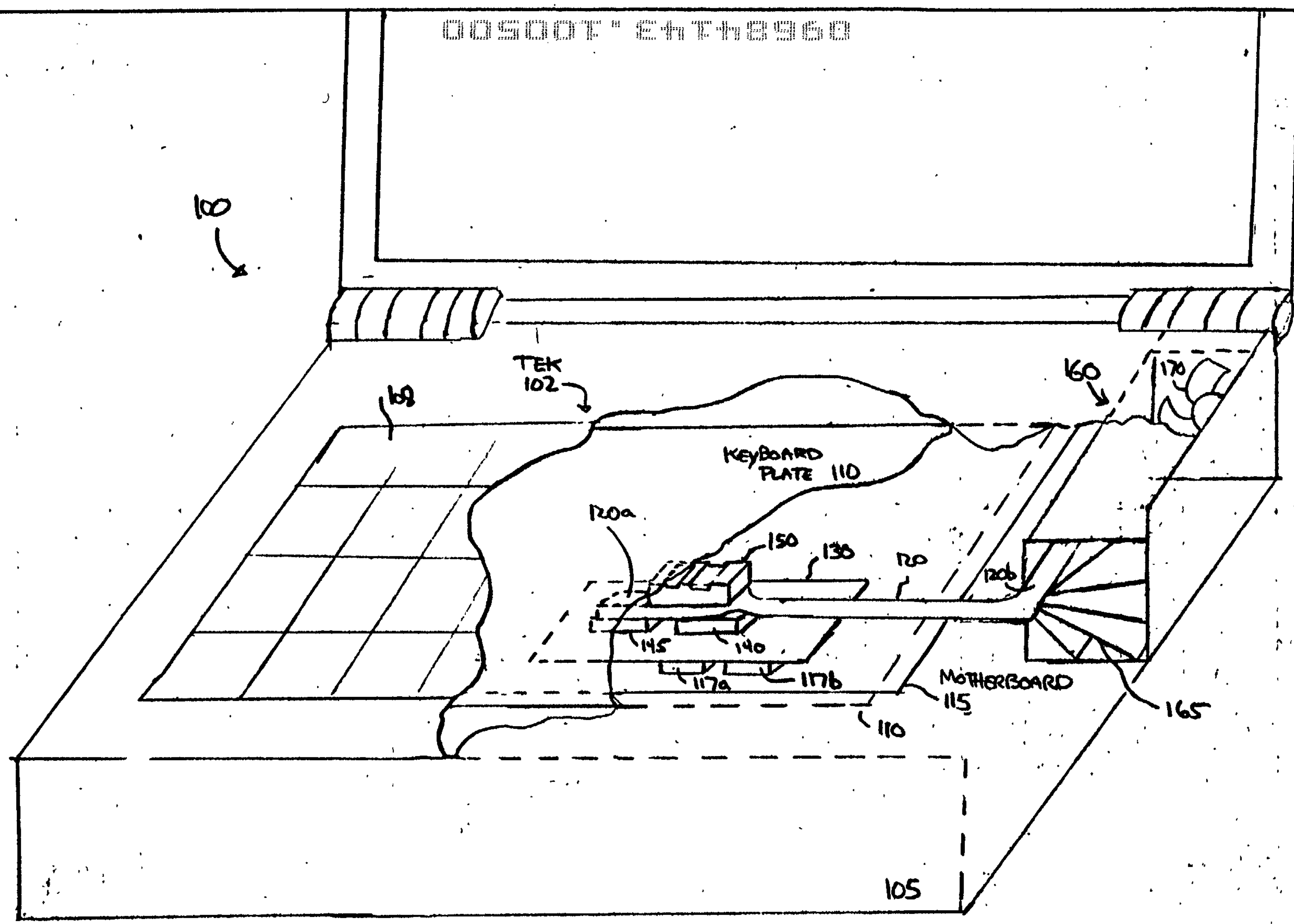
100
TEK
102
108
160
170
KEYBOARD
PLATE 110
120a
150
130
120
120b
145
140
117a
117b
MOTHERBOARD
115
110
165
105

FIGURE 1

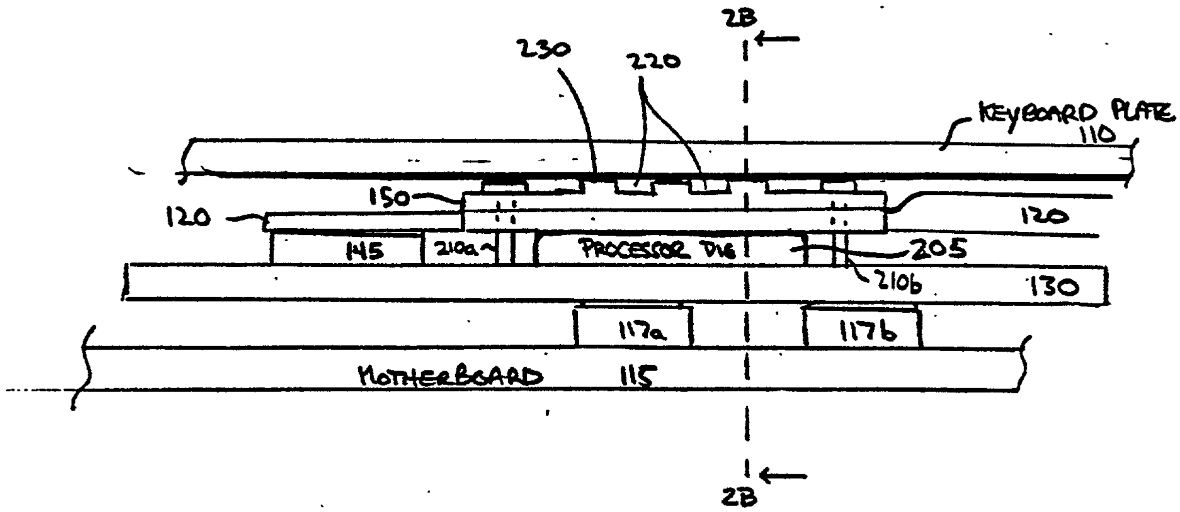

FIGURE 2A

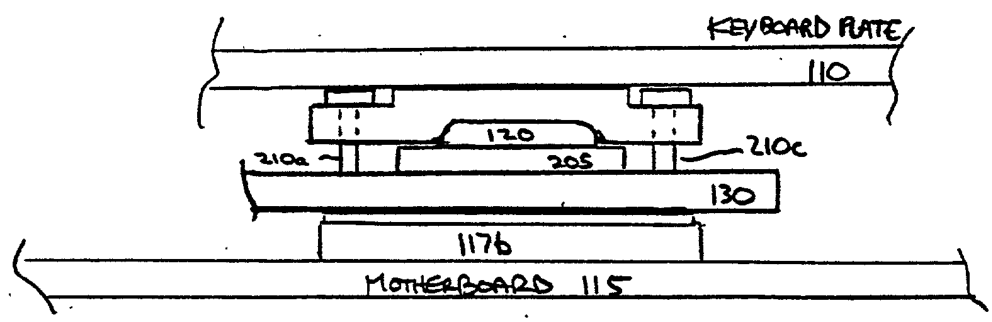

FIGURE 2B

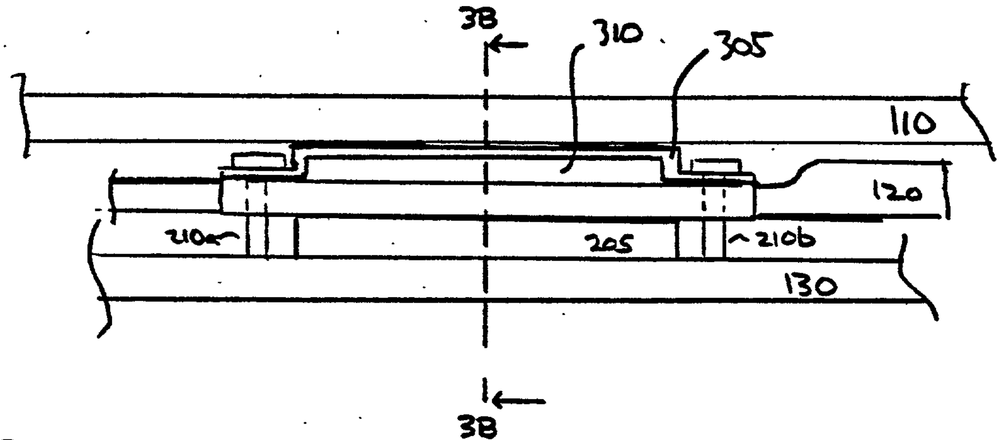

FIGURE 3A

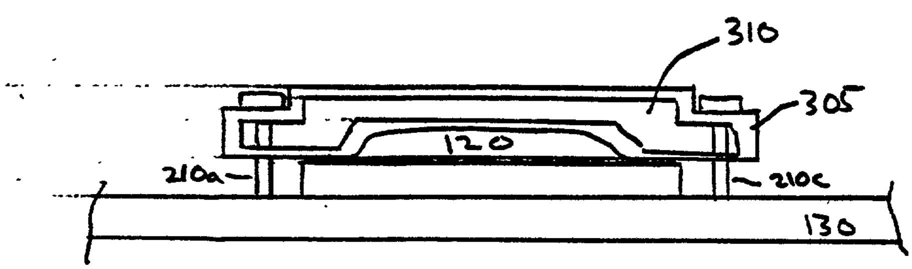

FIGURE 3B

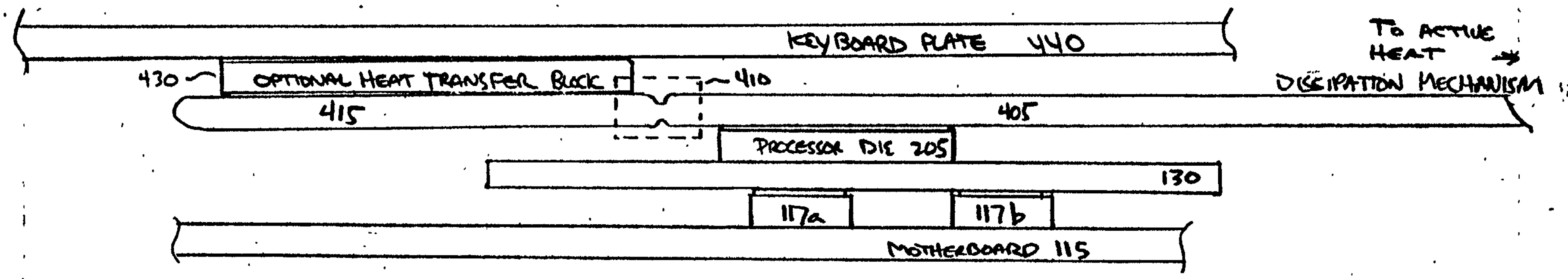
KEYBOARD PLATE 440
TO ACTIVE HEAT DISSIPATION MECHANISM
430
OPTIONAL HEAT TRANSFER BLOCK
410
415
405
PROCESSOR DIE 205
130
117a
117b
MOTHERBOARD 115

FIGURE 4

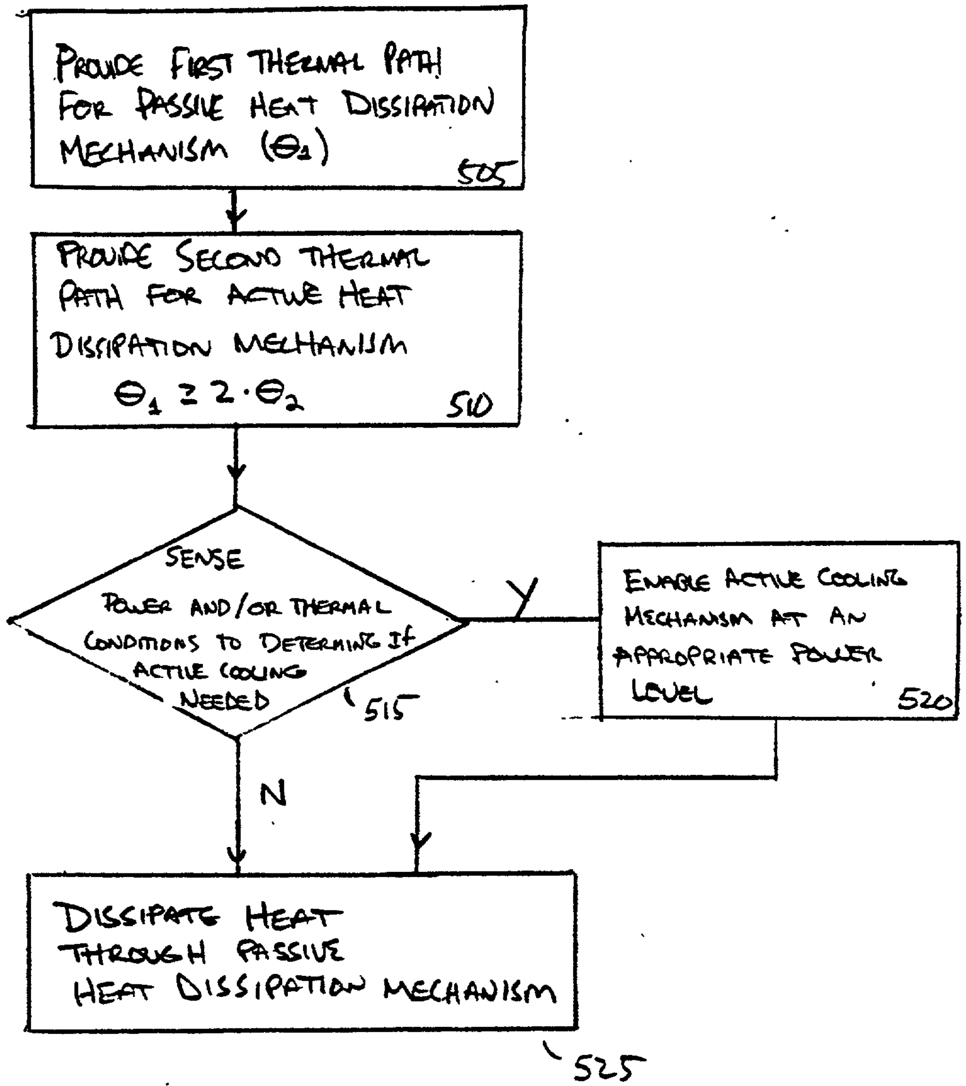
PROVIDE FIRST THERMAL PATH FOR PASSIVE HEAT DISSIPATION MECHANISM (Θ_1)
505
PROVIDE SECOND THERMAL PATH FOR ACTIVE HEAT DISSIPATION MECHANISM
$\Theta_1 \geq 2 \cdot \Theta_2$
510
SENSE POWER AND/OR THERMAL CONDITIONS TO DETERMINE IF ACTIVE COOLING NEEDED
515
Y
ENABLE ACTIVE COOLING MECHANISM AT AN APPROPRIATE POWER LEVEL
520
N
DISSIPATE HEAT THROUGH PASSIVE HEAT DISSIPATION MECHANISM
525

FIGURE 5

Attorney's Docket No.: 42390.P5698 PATENT

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION
(FOR **INTEL CORPORATION** PATENT APPLICATIONS)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

A HEAT EXCHANGER FOR A PORTABLE COMPUTING DEVICE UTILIZING ACTIVE AND PASSIVE HEAT DISSIPATION MECHANISMS

the specification of which

X is attached hereto.
___ was filed on ____________________ as
United States Application Number ____________
or PCT International Application Number ____________
and was amended on ____________________.
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to this application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Priority Claimed

Prior Foreign Application(s)

(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below

(Application Number)	Filing Date
(Application Number)	Filing Date

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Number)	Filing Date	(Status -- patented, pending, abandoned)
(Application Number)	Filing Date	(Status -- patented, pending, abandoned)

I hereby appoint Farzad E. Amini, Reg. No. P42,261; Aloysius T. C. AuYeung, Reg. No. 35,432; William Thomas Babbitt, Reg. No. 39,591; Jordan Michael Becker, Reg. No. 39,602; Bradley J. Bereznak, Reg. No. 33,474; Michael A. Bernadicou, Reg. No. 35,934; Roger W. Blakely, Jr., Reg. No. 25,831; Gregory D. Caldwell, Reg. No. 39,926; Kent M. Chen, Reg. No. 39,630; Lawrence M. Cho, Reg. No. 39,942; Thomas M. Coester, Reg. No. 39,637; Roland B. Cortes, Reg. No. 39,152; Barbara Bokanov Courtney, Reg. No. P42,442; William Donald Davis, Reg. No. 38,428; Michael Anthony DeSanctis, Reg. No. 39,957; Daniel M. De Vos, Reg. No. 37,813; Tarek N. Fahmi, Reg. No. 41,402; Richard Leon Gregory, Jr., P42,607; James Y. Go, Reg. No. 40,621; Sharmini Nathan Green, Reg. No. 41,410; David R. Halvorson, Reg. No. 33,395; Thomas A. Hassing, Reg. No. 36,159; Eric Ho, Reg. No. 39,711; George W Hoover II, Reg. No. 32,992; Eric S. Hyman, Reg. No. 30,139; Dag H. Johansen, Reg. No. 36,172; Stephen L. King, Reg. No. 19,180; Michael J. Mallie, Reg. No. 36,591; Paul A. Mendonsa, Reg. No. P42,879; Darren J. Milliken, P42,004; Thinh V. Nguyen, P42,034; Kimberley G. Nobles, Reg. No. 38,255; Michael A. Proksch, Reg. No. P43,021; Ronald W. Reagin, Reg. No. 20,340; Babak Redjaian, P42,096; James H. Salter, Reg. No. 35,668; William W. Schaal, Reg. No. 39,018; James C. Scheller, Reg. No. 31,195; Anand Sethuraman, Reg. No. P43,351; Charles E. Shemwell, Reg. No. 40,171; Maria McCormack Sobrino, Reg. No. 31,639; Stanley W. Sokoloff, Reg. No. 25,128; Allan T. Sponseller, Reg. No. 38,318; Steven R. Sponseller, Reg. No. 39,384; Geoffrey T. Staniford, P43,151; Judith A. Szepesi, Reg. No. 39,393; Edwin H. Taylor, Reg. No. 25,129; George G. C. Tseng, Reg. No. 41,355; Lester J. Vincent, Reg. No. 31,460; John Patrick Ward, Reg. No. 40,216; Ben J. Yorks, Reg. No. 33,609; and Norman Zafman, Reg. No. 26,250; my attorneys; and Robert Andrew Diehl, Reg. No. 40,992; and Edwin A. Sloane, Reg. No. 34,728; my patent agents, of BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP, with offices located at 12400 Wilshire Boulevard, 7th Floor, Los Angeles, California 90025, telephone (310) 207-3800, and Joseph R. Bond, Reg. No. 36,458; Richard C. Calderwood, Reg. No. 35,468; Cynthia Thomas Faatz, Reg No. 39,973; Sean Fitzgerald, Reg. No. 32,027; David J. Kaplan, Reg. No. 41,105; Leo V. Novakoski, Reg. No. 37,198; Naomi Obinata, Reg. No. 39,320; Thomas C. Reynolds, Reg. No. 32,488; Steven P. Skabrat, Reg. No. 36,279; Howard A. Skaist, Reg. No. 36,008; Steven C. Stewart, Reg. No. 33,555; Raymond J. Werner, Reg. No. 34,752; and Charles K. Young, Reg. No. 39,435; my patent attorneys, of INTEL CORPORATION; and James R. Thein, Reg. No. 31,710, my patent attorney; with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

Send correspondence to Michael J. Mallie, BLAKELY, SOKOLOFF, TAYLOR &
(Name of Attorney or Agent)
ZAFMAN LLP, 12400 Wilshire Boulevard, 7th Floor, Los Angeles, California 90025 and direct telephone calls to Michael J. Mallie, (408) 720-8598.
(Name of Attorney or Agent)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's Signature Rakesh Bhatia Date 02/20/98

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Inventor's Signature ____________________ Date ____________

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(City, State) (Country)

Post Office Address ____________________

Full Name of Fourth/Joint Inventor ____________________

Inventor's Signature ____________________ Date ____________

Residence ____________________ Citizenship ____________
(City, State) (Country)

Post Office Address ____________________